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A STUDY OF THE GRINDING CHARACTERISTICS OF A HUMBOLDT, PALLA 20U, VIBRATING MILL

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A STUDY OF THE GRINDING CHARACTERISTICS OF A HUMBOLDT, PALLA 20U, VIBRATING MILL

by

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SUMMARY

Grinding characteristics of a vibrating mill were studied using 0.42 mm (35 mesh) limestone as feed and 1.9 cm diameter by 1.9 cm long alumina cylpebs as grinding media. The operation variables investigated were:

1. feeding rate
2. grinding arrangement, i.e., the manner in which the two grinding chambers were connected.

Results showed that finer-grinding was achieved using slower feed rates and series grinding.

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ÉTUDE DES CARACTÉRISTIQUES DE BROYAGE DU BROYEUR VIBRANT HUMBOLDT PALLA 20U

S.S.B. Wang* et P.J.H. Prud'homme**

RÉSUMÉ

On a étudié les caractéristiques de broyage d'un broyeur vibrant; le matériau à broyer était du calcaire de 0,42 mm (maille 35) et la charge broyante, des galets cylindriques d'alumine de 1,9 cm de diamètre par 1,9 cm de longueur. Les variables d'exploitation de l'étude étaient:

1. la vitesse de l'alimentation
2. le circuit de broyage, c'est-à-dire le montage relatif des deux chambres de broyage.

Les résultats ont montré que le broyage le plus fin a été réalisé à faible vitesse d'alimentation en circuit série.

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OBJECTIVE

To study the grinding characteristics of a laboratory Humboldt "Palla U" vibrating mill.

DESCRIPTION OF UNIT

The Humboldt vibrating mill essentially consists of two horizontal steel cylinders mounted one above the other and linked by steel traverses. The grinding cylinders are set into transversal circular gyrations by a motor driven eccentric throw mechanism. The motor speed can be varied between 1000 and 1500 rpm. A speed of 1140 rpm was used in this study. In Fig. 1, which shows the main features of the Palla U system, the fan-shaped eccentric weights are exposed. The amplitude of vibration is established through the positioning of these weights which are four in number, two at each end of the mill with one fixed and the other free to rotate. Maximum amplitude is produced when the positions of fixed and movable weights correspond. There are a series of seven holes through both the fixed and movable weights. The two weights may be spread apart from the maximum position or securely bolted together through these holes in a series of settings. Maximum amplitude is obtained by bolting through the seventh hole. The designation "2 off minimum", which was the positioning of the weights adopted throughout this work, would indicate bolting through the fourth hole from the maximum position.

Both grinding cylinders are normally filled to 70% of this volume with grinding media. Available grinding media include two sizes of stainless steel balls, 1.9 cm and 1.3 cm; two sizes of high-density alumina cylpebs (cylinders), 1.9 cm diameter by 1.9 cm and 1.3 cm diameter by 1.3 cm; and 1.3 cm high-density alumina balls. It is necessary that both grinding cylinders receive exactly the same weight of grinding media. The 1.9 cm alumina cylpebs were selected for this study, 35.4 kg being loaded into each grinding cylinder which was lined with a plastic liner for iron free grinding. A steel liner is also available.

The flow of material can be regulated, to some extent, by weirs at the discharge ends, but in this work, the weirs were fully open.

The grinding cylinders can be operated in a parallel or in a series arrangement. In series, the sample is fed at one end of the upper cylinder, flows to the other end, falls into the lower cylinder, and then moves in the reverse direction discharging at the end of the lower chamber. In parallel operation the sample is fed at the same end of both cylinders and discharges at the opposite end. A more detailed description of this mill can be found elsewhere (1). In this test series, feed was introduced by a closely controllable, vibrating feeder.

SAMPLES

Limestone from Fort McMurry, Alberta was crushed in a jaw crusher and ground to about 0.42 mm (35 mesh) in a swing sledge mill and sieved on a 35 mesh screen. The plus 0.42 mm portion was used in the Humboldt study.

PROCEDURE

Four tests were carried out, two each for series and parallel grinding. Two feeding rates were used in each, one at 450 g/min, the other at 250 g/min. The experimental procedure was as follows:

1. Loaded 35.4 kg of 1.9 cm alumina cylpebs into each of the grinding cylinders.

2. Started the unit; checked and established the motor speed at 1140 rpm.

3. Fed sample at the pre-selected rate; making periodic cuts of the feed stream at 20, 30 and 40 min after start of feeding and combined these cuts to form head sample for sieve analysis.

4. Noted the time when the ground product emerged from the discharge end; collected product samples at 20, 30 and 40 min for sieve analysis.

5. The amount of feed was selected so that it required 50 min feeding time. The mill was kept running for 15-20 min after the end of feeding to allow complete discharge.

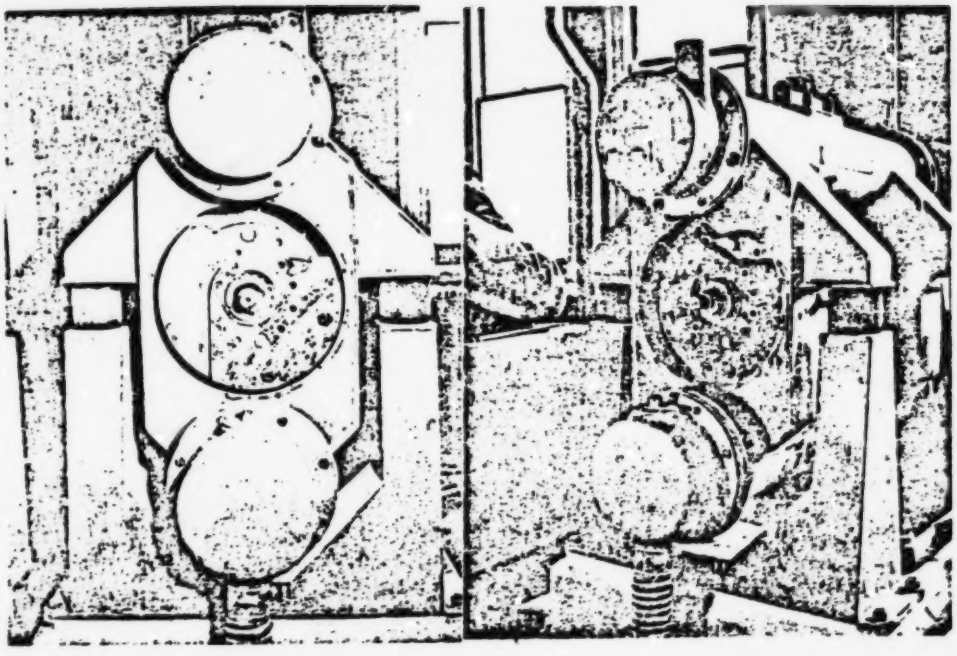

Fig. 1 - The Humboldt vibrating mill showing amplitude mechanism

Wet sieve analyses were performed on the feed sample, on the three product samples, and on a representative combined sample of the three product samples. A wet micro sieve analysis was carried out on the minus 45 μm portion of the combined product sample.

RESULTS AND DISCUSSION

Size analyses of the feed and product samples for the four tests are presented in Tables 1-4 and in Fig. 2-5. Feed averaged about 80% plus 50 μm; parallel grinding, at a feed rate of 450 g/min, reduced sample to about 70% minus 50 μm and, at 250 g/min, to 80% minus 50 μm; series grinding, by contrast, reduced sample to 90% minus 50 μm at 450 g/min and to almost 98% minus 50 μm at a feed rate of 250 g/min. Comparative productions of minus 5 μm product were 4.7, 7.6, 17.8 and 40.5%. Thus fine grinding to 5 μm and less with limestone will necessitate series grinding at feed rates of 250 g/min and less. The results show that the product fineness depends on the feed rate and the grinding arrangement. As the feed rate decreases, finer products are obtained. Slower feed rates result in longer retention time in the mill, longer exposure to grinding, and consequently, finer products. The series grinding arrangement, which provides longer retention time, gives finer products than when the unit is operated in parallel mode. By regulating the retention time in the mill, a wide range of product fineness and throughput capacity can be achieved.

In conclusion, the Humboldt Pall U vibrating mill with plastic liner and alumina cylpebs as grinding media is ideal for fine grinding industrial minerals with minimum iron contamination. Further work is recommended to study other operation variables such as vibration frequency and amplitude, weir opening, and media type and load, to ultimately determine the optimum operation conditions for grinding various industrial minerals.

REFERENCES

1. Hartman, F.H. and Wyman, R.A. "Operating characteristics of a vibrating mill"; Mines Branch Technical Bulletin TB 94; CANMET, Energy, Mines and Resources Canada; 1967.

Table 1 - Size analysis, Test 1*

Sieve Size µm	Feed		PRODUCT									
			No. 1 20 min		No. 2 30 min		No. 3 40 min		No. 4 No. 1,2,3 Blended		No. 5 -50 µm from No. 4	
	%	**CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %
+ 160	73.7	73.7	3.1	3.1	7.8	7.8	2.9	2.9	10.1	10.1		
-160 + 100	2.1	75.8	5.1	8.2	7.3	15.1	4.5	7.4	7.4	17.5		
-100 + 70	1.5	77.3	7.8	16.0	8.1	23.2	8.3	15.7	9.6	27.1		
- 70 + 50	1.5	78.8	9.5	25.5	9.7	32.9	9.8	25.5	7.9	35.0		
- 50	21.2	100.0	74.5	100.0	67.1	100.0	74.5	100.0	(65.0)	(100.0)		
- 50 + 22									11.2	46.2	17.2	17.2
- 22 + 11									28.3	74.5	43.5	60.7
- 11 + 5									22.5	97.0	34.6	95.3
- 5									3.0	100.0	4.7	100.0

* Grinding arrangement - Parallel grinding
  Feed rate - 450 g/min
**Cumulative %

Table 2 - Size analysis, Test 2*

Sieve Size µm	Feed		PRODUCT									
			No. 1 20 min		No. 2 30 min		No. 3 40 min		No. 4 No. 1,2,3 Blended		No. 5 -50 µm from No. 4	
	%	**CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %
+ 160	74.9	74.9	1.5	1.5	0.8	0.8	0.7	0.7	1.0	1.0		
-160 + 100	1.8	76.7	2.8	4.3	1.6	2.4	1.9	2.6	2.1	3.1		
-100 + 70	1.3	78.0	7.1	11.4	4.8	7.2	6.0	8.6	4.5	7.6		
- 70 + 50	1.6	79.6	10.4	21.8	11.1	18.3	10.6	19.2	9.2	16.8		
- 50	20.4	100.0	78.2	100.0	81.7	100.0	80.8	100.0	(83.2)	(100.0)		
- 50 + 22									12.6	29.4	15.2	15.2
- 22 + 11									21.0	50.4	25.3	40.5
- 11 + 5									43.2	93.6	51.9	92.4
- 5									6.4	100.0	7.6	100.0

* Grinding arrangement - Parallel grinding
Feed rate - 250 g/min
**Cumulative %

Table 3 - Size analysis, Test 3*

Sieve Size µm	Feed		PRODUCT									
			No. 1 20 min		No. 2 30 min		No. 3 40 min		No. 4 No. 1,2,3 Blended		No. 5 -50 µm from No. 4	
	%	**CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %
+ 160	72.6	72.6	0	0	0	0	0.2	0.2	0.1	0.1		
-160 + 100	1.9	74.5	0.2	0.2	0.2	0.2	0.7	0.9	0.4	0.5		
-100 + 70	1.7	76.2	1.1	1.3	1.3	1.5	3.1	4.0	1.7	2.2		
- 70 + 50	2.0	78.2	6.3	7.6	5.4	6.9	7.5	11.5	6.7	8.9		
- 50	21.8	100.0	92.4	100.0	93.1	100.0	88.5	100.0	(91.1)	(100.0)		
- 50 + 22									12.0	20.9	13.2	13.2
- 22 + 11									36.2	57.1	39.7	52.9
- 11 + 5									26.7	83.8	29.3	82.2
- 5									16.2	100.0	17.8	100.0

* Grinding arrangement - Series grinding
  Feed rate - 450 g/min
**Cumulative %

Table 4 - Size analysis, Test 4*

Sieve Size µm	Feed		PRODUCT									
			No. 1 20 min		No. 2 30 min		No. 3 40 min		No. 4 No. 1,2,3 Blended		No. 5 -50 µm from No. 4	
	%	**CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %	%	CUM %
+ 160	73.1	73.1	0	0	0	0	0	0	0	0		
-160 + 100	1.9	75.0	0	0	0	0	0	0	0	0		
-100 + 70	1.3	76.3	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3		
- 70 + 50	1.7	78.0	1.9	2.1	2.2	2.4	2.0	2.2	1.8	2.1		
- 50	22.0	100.0	97.9	100.0	97.6	100.0	97.8	100.0	(97.9)	(100.0)		
- 50 + 22									8.3	10.4	8.5	8.5
- 22 + 11									16.8	27.2	17.2	25.7
- 11 + 5									33.1	60.3	33.8	59.5
- 5									39.7	100.0	40.5	100.0

* Grinding arrangement - Series grinding
  Feed rate - 250 g/min
**Cumulative %

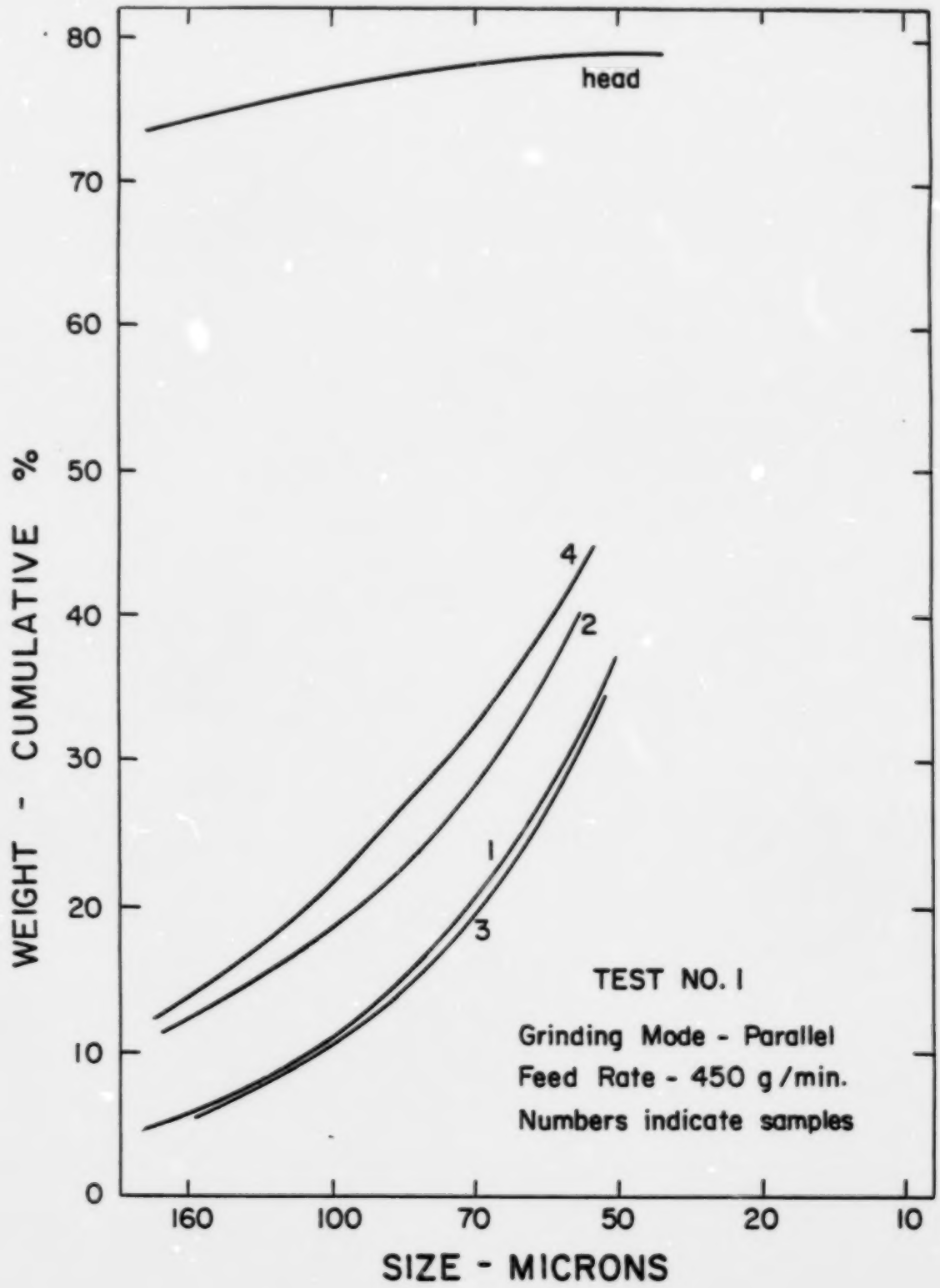

Fig. 2 - Size distribution of samples

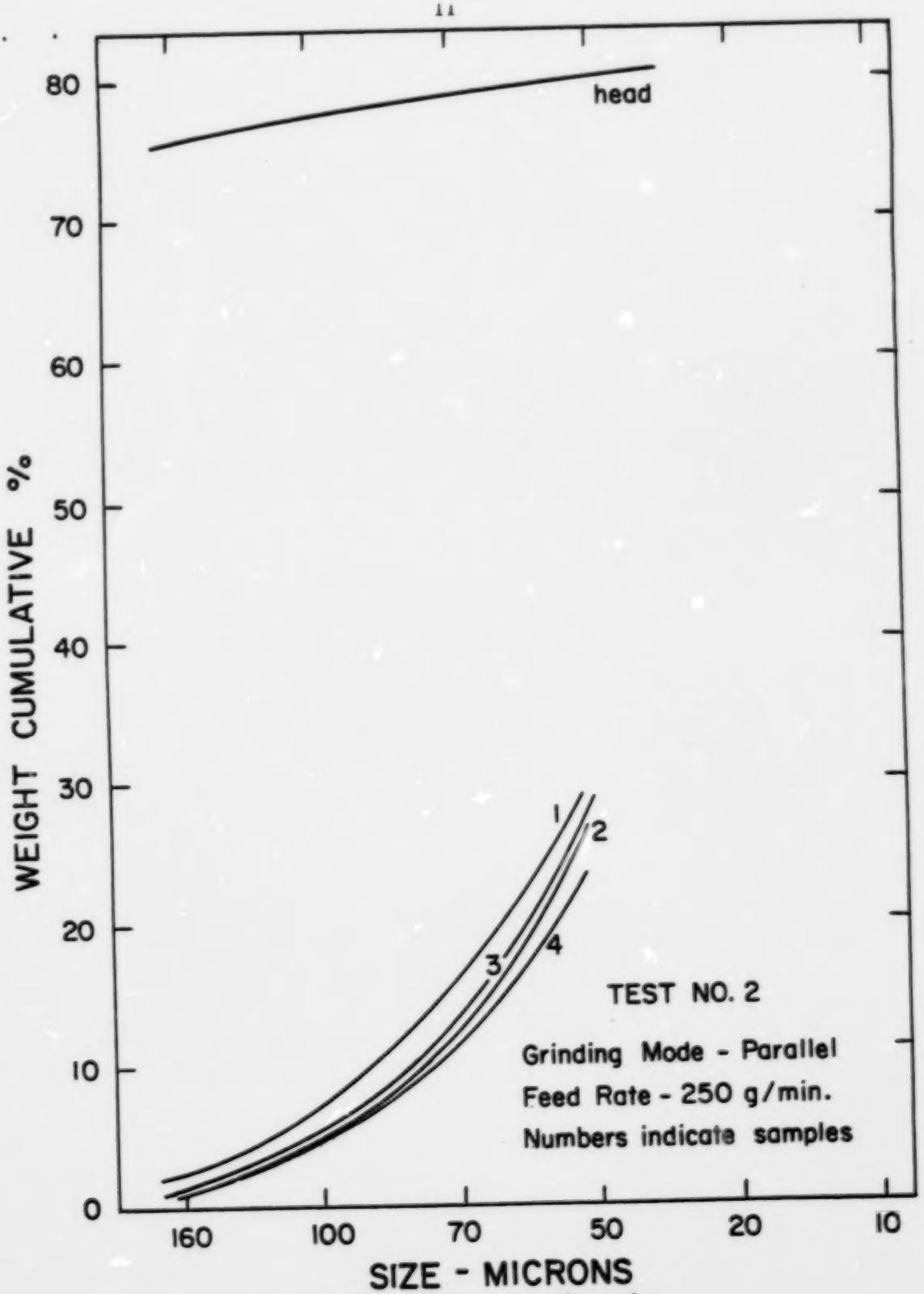

Fig. 3 - Size distribution of samples

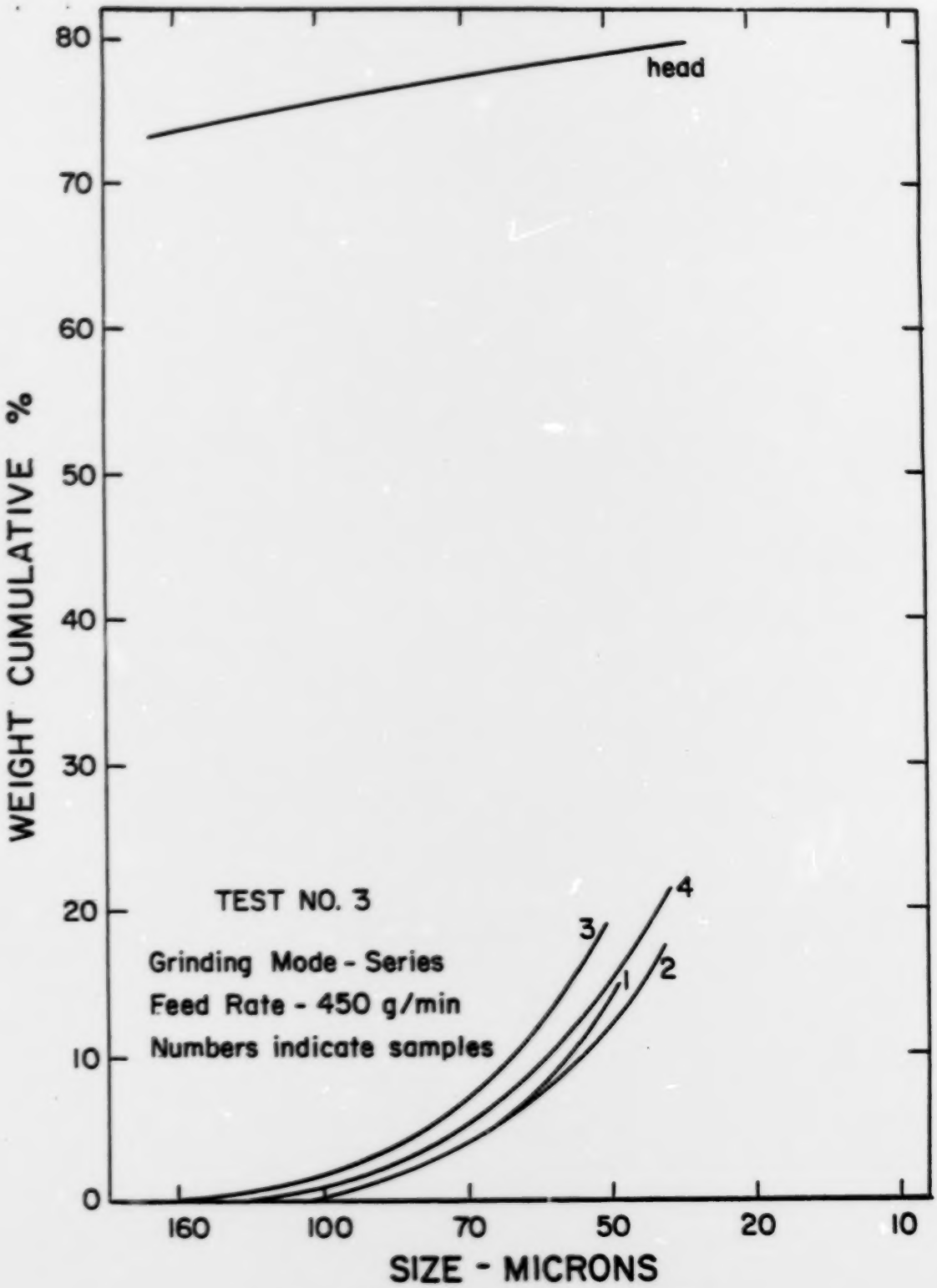

Fig. 4 - Size distribution of samples

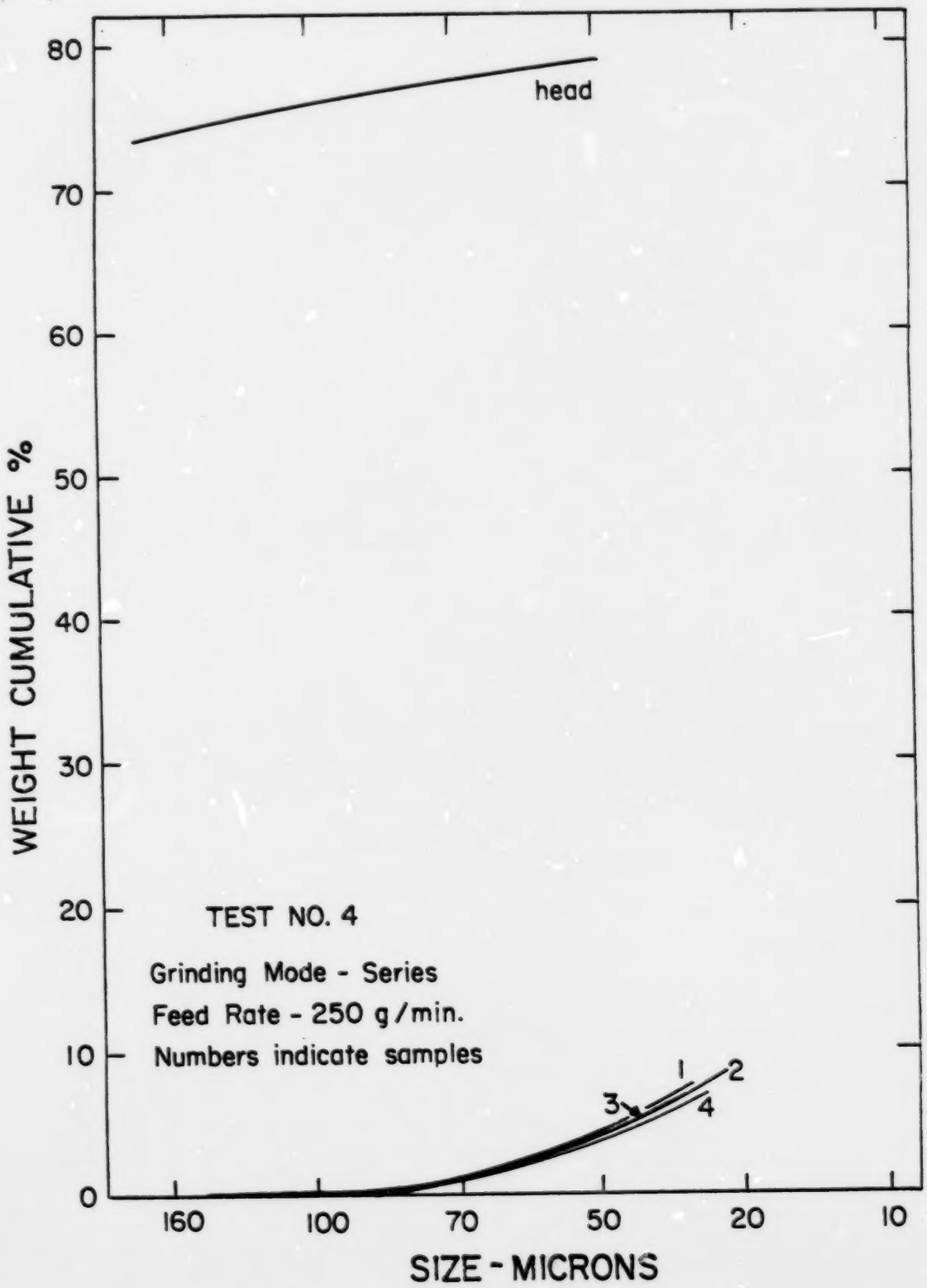

Fig. 5 - Size distribution of samples